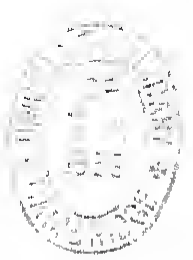
MINISTRY OF
LABOUR AND NATIONAL SERVICE
H.M. FACTORY INSPECTORATE

Fourth Report of Proceedings of the
Joint Standing Committee on

Safety in the use of Power Presses



LONDON
HER MAJESTY'S STATIONERY OFFICE
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INTRODUCTION

In their Third Report, the Joint Standing Committee referred to faults in electro-pneumatic control systems of presses which had led to uncovenanted stroking and stated that a special Sub-committee had been appointed to examine the whole problem. In this Fourth Report, the report of the Sub-committee is included together with certain other information on developments which took place after the Sub-committee had reported.

Electro-pneumatic or electrical methods of control of power press clutches are particularly associated with the use of friction clutches and it has been noted that in recent years there has been a tendency to employ such clutches on smaller presses where hitherto the positive clutch has been almost invariably employed. While the investigations of the Sub-committee largely took place in relation to the larger slow running presses where friction clutches have long been the usual mould of operation, it is felt that what is said in the Report has validity for all cases where friction clutches are employed and controlled by electrical or electro-pneumatic means.

The Report and the recommendations in particular are of importance both to manufacturers of presses and to their users and it is hoped that the work which has been done will result in the general adoption of the recommendations. It is recognised that some development work will still have to be undertaken, but it is thought that sufficient is said in the Report to give an adequate lead.

The Joint Standing Committee is particularly grateful for the unstinted attention given by the Sub-committee to its task.

9th January, 1959

To H.M. Chief Inspector of Factories

SIR,

1. In our Third Report, at paragraph 17, we referred to faults in the operation of presses whose clutch mechanisms were controlled by electro-pneumatic means, and where reliance for safety was placed on guards controlling the electrical system. We also stated that H.M. Chief Inspector of Factories had appointed a Sub-Committee to review this matter. The Sub-Committee was given the following terms of reference:

> "to consider the methods of control of friction clutch-operated presses, to consider recommendations and to report".

We have now received the Report of the Sub-Committee and this we attach as Annexe I to this Report as received. We consider that the Report is an important contribution to furthering the safe working of power presses and we recommend that it should be published. For reasons which are explained below, we have not thought fit to support all the recommendations but it should not be assumed from this that we reject any particular recommendation; rather we feel that in practice there must be a limit to the extent to which firm recommendations may be demanded. Nevertheless, we commend all such proposals to the careful study of designers. We feel that if manufacturers of presses and control equipment are prepared to follow the recommendations there should be enhanced reliability as well as some beneficial standardisation of such items as control buttons and other equipment which have to be handled on the shop floor. In considering the Report of the Sub-Committee, we have also borne in mind that direct mechanically controlled and operated friction clutches are in use. We consider that for this type of mechanism the recommendations made in Appendix 5 of our First Report of Proceedings remain as a sound standard.

2. In submitting their Report, the Sub-Committee urged upon us the desirability of bringing their recommendations before those concerned with design and equipment of presses, at an early date. We agree, and accordingly copies of the Report have been sent to the British Power Press Manufacturers' Association, the British Electrical and Allied Manufacturers' Association and the Compressed Air Society. If this Report is published before any one of the above bodies have expressed any views, and they subsequently make comments, we shall be glad to consider these.

3. The Sub-Committee has made recommendations covering air and electrical equipment and clutch and brake design. These are contained respectively in Appendices 1, 2, 3 and 4. All of these we accept and recommend them for adoption by manufacturers and users of presses. We would, however, comment on the reference to balancing in Recommendation 5 of Appendix 1. It is the practice to use air balancing on some presses whose clutches are not operated by pneumatic means. In such cases, loss of air pressure in the balancing system has been known to lead to dangerous conditions.

An overall general requirement which applies to all electrical equipment, where a failure might affect the safety of personnel, is that it should be of the highest grade construction, prudent design and liberal rating. A degree of reliability and integrity may be desirable above that which suffices where no question of personal risk is involved.

4. An outstanding recommendation of the Sub-Committee is the proposal that presses which are driven through friction clutches which are electrically or electro-pneumatically controlled should be fitted with a special device aimed at preventing

a press from making a stroke other than the one normally intended by operation of the operator's control. It is known, for example, that a press which has an electrically controlled clutch will repeat if the limit switch which is intended to bring the stroke to a conclusion should fail to function. Equally, a failure of a solenoid controlled air valve to operate properly at the end of the cycle will cause a repeat. A solenoid which sticks mechanically after de-energising is an example of how such an improper operation of the valve could take place. In Appendices 5 and 6 of the Sub-Committee's Report there are descriptions and illustrations of these overriding anti-repeat devices. The underlying principle is that an additional valve should be provided and installed in such a way that if the press should attempt an unexpected stroke this valve will be open to discharge the air from the clutch cylinder supply pipe, thereby relieving the operating cylinder and allowing the clutch to be immediately disengaged and the brake applied. Where the clutch and brake are independently operated, a separate valve will be required for each item. Throughout its discussions the Sub-Committee has tried to avoid reference to guarding arrangements, taking its terms of reference to be limited to matters which are concerned with the presses themselves. In Appendix 5, however, there is a description of a mechanically operated anti-repeat device which is connected to a guarding system. This is merely because the early developments took place on a machine for which a guard was necessarily provided. We are glad to report that an effective mechanically operated overriding anti-repeat device has now been fitted independently of the guarding system. We have examined this arrangement, and are satisfied that it forms a good illustration of a positive mechanical system, which could be provided by the maker without reference to the type of guard to be fitted. This arrangement is described and illustrated in Annexe II.

5. We have had to recognise, as did indeed the Sub-Committee, that there might be considerable practical difficulties in the fitting of a mechanically operated overriding anti-repeat arrangement, and it may therefore be the case that electrically operated devices must be considered as alternatives. Certain members of the Sub-Committee have, in fact, designed and installed apparatus of this kind, and one example is illustrated and described in Appendix 6. As such an arrangement involves the installation of further electrical equipment additional to an already complicated control circuit, great care must be taken in establishing reliable standards. We think that such care has been shown in the example described, but we feel that we should re-emphasise the views of the Sub-Committee expressed in paragraphs 9 and 12 of their Report which underlines the importance of aiming at a standard of performance as good as the simple mechanical arrangement which we have included as Annexe II. In our view, the achievement of such equivalence by electrical means is a distinctly difficult matter and we must make clear our definite preference for the mechanically operated arrangement.

6. Most experience in connection with the use of electrically or pneumatically operated clutches in this field is confined to those large slow running machines which are used typically for motor car panel work. As a consequence, therefore, much of the work done by the Sub-Committee was related to experience with such machines. We know, however, that in the range of small and medium sized open fronted presses, friction clutches are being used or may be used to an increasing extent. For such machines, it will be necessary to devise a guard of the "interlocking" type equivalent in performance at least to the mechanically interlocked guard which is in general use on positive key clutch machines. Where, however, an electrically operated friction clutch is involved the guard will only effect a control over the electrical circuit of the clutch mechanism. We do not consider that this is entirely satisfactory, and our view is that the recommendations made by the Sub-Committee in particular with regard to the provision of an overriding anti-repeat device to prevent an uncovenanted stroke as stressed in paragraph 4 above, should be fully applicable to these smaller machines.

7. In paragraph 5 of their Report, the Sub-Committee refer to the desirability of specifying brake performance. After careful consideration and taking into account the views of a number of manufacturers, they concluded that they were unable to make a formal recommendation but suggested that efforts in this direction should not be abandoned. We agree with this view. A specified braking performance would be a helpful contribution to safety and we recommend that makers of presses should provide such information. The braking performance should be plainly marked on each machine and should be included also in the specification furnished to a customer. The performance should take into account the maximum suspended weight which the maker considers appropriate and this maximum suspended weight should be stated as a part of the notice indicating the braking performance.

(*Note*: A corollary of this recommendation is that the suspended weight should never exceed the maximum specified by the maker.)

8. In paragraph 10 of their Report and also at Appendix 7, the Sub-Committee refer to a brake application detector unit. We have considered very carefully whether we should make the provision of this arrangement the subject of recommendation. We recognise that the device provides an additional precautionary measure in that brake failure would result in inability to open a guard during the consequent over-run. We are not, however, satisfied that this arrangement would be practicable in all types and ranges of press which we are dealing with and we are impressed with the importance of securing as much standardisation as possible. In the circumstances, we therefore prefer the matter to be left as one of which designers should take note as being a further useful contribution to safety. It will be noted that the arrangement is associated with a guard and throughout our consideration of the present subject, we have tried to look at the matter independently of guarding.

9. The Sub-Committee comments, in paragraph 11, on a device described in Appendix 8 of their Report, which aims at detection of faulty operation of a control valve. A spool valve actuated by a pilot system is provided with a constant pressure bias towards exhaust or clutch disengaging position. The arrangement is such that the valve will move to this position in the event of individual faults occurring which would otherwise lead to faulty operation of the clutch. A combination of faults could, however, still lead to a dangerous situation and the designers have, therefore, added an electrical monitoring system. We recognise that the arrangements have much to commend them.

10. Consideration of these problems has taken a long time. The Sub-Committee had an immense amount of material placed before them both on design and practice and many unusual features were, therefore, brought to light. The members of the Sub-Committee deserve the thanks of industry for giving their time, knowledge and experience so freely and, in particular, for drawing upon the services of their own experts. Many of these gentlemen came to the meetings of Committee and gave invaluable help. Again, Mr. R. K. Mawson, the Secretary, has made an immense contribution to the work by his very wide technical knowledge and experience. He has also investigated a number of specific problems, which came to light, with particular industry and efficiency.

Signed: R. BRAMLEY-HARKER (*Chairman*)
W. H. L. BROGDEN
H. D. CHALLEN
N. ELLIOTT
JOHN R. MOORE
A. L. STUCHBERY
J. D. UDAL
R. K. MAWSON (*Secretary*).

ANNEXE 1

Sub-Committee on Methods of Press Control

1. We were appointed as a Sub-Committee of the Joint Standing Committee on Safety in the use of Power Presses in April, 1955, with the following terms of reference:

To consider methods of control of friction clutch operated presses, to consider recommendations and to report.

We held our first meeting on 20th May, 1955. The original members of the Sub-Committee were:

Mr. R. Bramley-Harker –	H.M. Deputy Chief Inspector of Factories (*Chairman*)
Mr. W. H. L. Brogden –	Pressed Steel Co. Ltd., Oxford
Mr. N. Elliott – –	H.M. Electrical Inspector of Factories
Mr. W. F. Fellows –	The Wellman Smith Owen Engineering Corporation Ltd.
Mr. E. C. Houghton –	Vickers-Armstrongs (Engineers) Ltd.
Mr. J. F. Millard –	Nuffield Metal Products Ltd.
Mr. T. H. Pattison –	Wilkins and Mitchell Ltd.
Mr. E. C. Seed – –	Cowlishaw Walker and Co. Ltd.
Mr. J. D. Udal – –	J. P. Udal Ltd.
Mr. P. Zierold – –	Briggs Motor Bodies Ltd.
Mr. R. K. Mawson –	H.M. Engineering Inspector of Factories (*Secretary*).

2. In addition to the original members, Mr. A. V. Cassanet, representing Gaston E. Marbaix Ltd., joined the Sub-Committee in February, 1956.

The following gentlemen have also attended meetings either as substitutes or as Technical Advisers to Members:

Mr. S. J. Emerson –	H.M. Senior Electrical Inspector of Factories
Messrs. J. Higgins and J. A. Pope	Briggs Motor Bodies Ltd.
Mr. A. W. Hancox –	Nuffield Metal Products Ltd.
Mr. V. Hill – –	Pressed Steel Co. Ltd.
Mr. D. Holding – –	Cowlishaw Walker and Co. Ltd.
Mr. G. M. Leighton –	H.M. Electrical Inspector of Factories
Mr. K. Mittlestrass –	The Wellman Smith Owen Engineering Corporation Ltd.

The Sub-Committee has also been fortunate in having the attendance at several meetings of Mr. J. E. Rowe of the Ross Operating Valve Company, Detroit, and Mr. E. K. Morgan of Danly Machine Specialties, Inc. These gentlemen gave valuable advice to the Sub-Committee on aspects of American practice. The Sub-Committee has also received valuable criticism from the National Tool Builders Association.

3. 19 meetings have been held, alternately in Birmingham and London. There has been substantially full attendance at all meetings and, where Members have been unable to attend, substitutes have been present.

4. In considering our terms of reference, we concluded that our aim should be to improve the reliability of operation of friction clutch operated presses, bearing in mind that guards for the trapping areas would often be associated with the means by which the machines are controlled. We had particularly in mind the need to prevent the possibility of repeat strokes. It was decided that the matters for consideration fell under the following headings:

(*a*) Air Supply
(*b*) Air Control Equipment
(*c*) Electrical Equipment
(*d*) Clutch
(*e*) Brake

Agreed recommendations on these matters are set out in Appendices 1 - 4.

5. In the course of our consideration of friction clutch and brake design, we felt that it was desirable that there should be a recommendation in regard to overall braking performance. We felt that as far as possible there should be uniformity in this matter and that it would be of great value to users of presses if they knew the performance of the brake as designed and provided for by the manufacturer. Periodic checking of the braking performance would then afford an indication as to the efficiency with which the equipment was fulfilling its duty. We thought that it would be possible to frame a recommendation on the basis that from the time of breaking the first contact in the control circuit, i.e., the operators clutch stop button, the slide would be brought to rest in a specified angular movement of the crankshaft measured when the slide was moving at maximum speed. Manufacturers were consulted about this proposal and while some stated that such a proposal was reasonable and practicable, others drew attention to the wide range of presses both in terms of speed and capacity which are operated through friction clutches, and doubts were expressed as to whether a single standard could be proposed which would be practicable throughout the range. We are informed that at least one American manufacturer of presses, such as are used in motor car panel work, arranges his designs so that the crankshaft is brought to rest by braking action in not more than 30°. In view however of the difficulties and doubts raised on this matter, we have felt unable to make a specific recommendation, but we think that the matter ought to be pursued and we suggest to the Joint Standing Committee that there should be further efforts made to devise an agreed recommendation.

6. A substantial amount of time has been devoted to the consideration of electrical matters. It was represented to us that in a number of directions there were possibilities of failure which could lead to repeat strokes, the prevention of which would depend upon the introduction of cettain techniques which are comparatively new. A sticking contactor for instance could result in a repeat stroke, even though other elements in the control circuit were performing normally. Schemes have been described to us which would deal with such conditions and further development work is in progress. We feel, however, that our Repott would be unduly delayed if we were to await the full practical development of these proposals.

During our discussions on push button design, a case came to our notice in which a stop button incorporating an auto-lock feature had been found to be locked out thereby preventing the button from fulfilling its purpose. We would commend strongly to makers the impottance of ensuring that their designs are proof against such mal-operation.

7. At an early stage in our deliberations, all press makers who were known to manufacture presses with friction clutches, other than those represented on the Sub-Committee, were approached for their views. Two makers replied helpfully but the response from others was not very satisfactory.

8. At our Seventh Meeting, we felt that one matter should be communicated to press makers immediately. This was a recommendation that solenoid design

should be such that operation electrically would not be possible unless the cover was in position. It had been reported to us that covers were often left off solenoids with the consequence that foreign matter was apt to intrude and interfere with the working of the equipment. We understand that equipment conforming to this requirement is not at present available from British Manufacturers and it was therefore felt to be important that press makers should know of this recommendation as soon as possible so that designs could be worked out at an early date.

9. Throughout our discussions, we have recognised that even with the best standards of equipment and installation, as a result of failure of an individual item, e.g., a control valve or an electrical limit switch, a repeat stroke might occur with serious consequences to an operator. We have therefore considered whether an overriding means of preventing such strokes was a practicable possibility. One of our members had demonstrated that successful employment of an emergency discharge valve interposed between the normal control valve and the clutch cylinder whereby in the event of an attempted repeat stroke, the cylinder supply pipe is opened to atmosphere, so that the clutch is immediately disengaged and the brake applied. This arrangement has been operated in conjunction with a guard which provides the necessary mechanical means for operating the emergency valve. The arrangement is illustrated and described in Appendix 5. We felt that it would be practicable to explore the possibility of recommending such a valve as a standard fitting on all presses of the type we were considering. It would be necessary, however, to envisage such a valve as being independent of the guarding arrangements. Another of our members demonstrated in practical form an arrangement fitted to a large press which has given us further valuable data. In this case a pilot operated emergency cut-off valve was installed adjacent to the clutch cylinder and the electrical arrangements for operating the solenoid of this valve were so contrived that in the event of failure of the control gear to function correctly, the valve opened the clutch cylinder pipe to atmosphere and a threatened repeat was prevented. This arrangement is illustrated and described in Appendix 6. A feature which we regard as fundamental, is that failure of electrical supply to the solenoid operating the emergency valve should lead to operation of the valve. We take the view that any arrangements on these lines should have as their aim equivalence in performance to a positive mechanical system.

10. In the course of our deliberations, we have also learned of other valuable contributions to the establishment of safe conditions for the operator. At one large factory, an arrangement is provided which ensures that a guard may not be open unless the brake is fully applied. This is achieved by interlocking a cut-off valve with the guard. The movement of this valve is controlled by compressed air taken from the main supply to the press and so arranged that only when the brake discs have closed fully can the valve be moved to unlock the guard. This arrangement is illustrated and described in Appendix 7.

11. Another principle which has obvious merits is that of detection of faulty operation and we have had described to us a system which has been applied to a pilot operated control valve. Faulty electrical operation results in the valve being moved to a position corresponding to clutch disengagement. The arrangement is illustrated and described in Appendix 8.

12. After very careful consideration it was concluded that there were sound grounds for recommending the provision of emergency arrangements on the lines referred to in paragraph 9 and accordingly we make the following proposal:

Presses controlled by air-operated friction clutches should be provided with arrangements to prevent repeat strokes. Such arrangements should include a valve (or valves) fitted in the supply pipe to the clutch cylinder which will be automatically opened to discharge the air from the clutch cylinder if the press should attempt to make a repeat stroke. Where separate arrangements are

provided for the control of the brake, the foregoing arrangements should be extended to ensure full application of the brake under the conditions specified.

Note.—Attention is drawn to the value of an emergency valve positively operated in a mechanical manner, and which is so arranged as to be biased to safety by the internal pressure of the system. Arrangements which do not embody positive mechanical operation should aim at equivalence therewith.

Signed: R. BRAMLEY-HARKER (*Chairman*)
W. H. L. BROGDEN
A. V. CASSANET
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E. C. HOUGHTON
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E. C. SEED
J. DAVY UDAL
R. K. MAWSON (*Secretary*)

APPENDIX 1

Compressed Air Supply for the Operation of Friction Clutches

1. Every press should bear a prominent plate stating the minimum designed working pressure for operation of the clutch.

2. There should be provided a supply of compressed air at each press, adequate in quantity and of sufficient pressure to enahle the press to be operated at the minimum designed pressure. A pressure gauge should be fitted in the supply line. Arrangements should he provided to ensure that, if pressure falls below the minimum designed pressure specified by the maker, the control circuit shall be made dead.

3. In the supply pipe to each press there should he fitted a strainer or other device capahle of removing effectively from the air, moisture and solid foreign matter such as corrosion scale. Appropriate means should be provided for draining off water collected by the straining device, and for the removal of solid foreign matter. There should he a suitable drain trap in an appropriate position. Any piping situated beyond the point where moisture and solid foreign matter is removed should be made of a material which is not subject to corrosion.

4. Where valves or other working parts of the press control system require lubrication, visual automatic means of lubrication should he provided to introduce the oil into the air line in suitahle form. The arrangements should he of such a nature that they will only operate when air is flowing. The luhricator and the equipment referred to in paragraph 3 should be placed as close as possihle to the main clutch control valve, but should be readily accessible and visihle.

5. Where a press is equipped with halancing arrangements dependent on compressed air, either a receiver of adequate size should be provided at the press to act as a surge tank and to ensure the maintenance of a sufficient supply of air for the operation of the machine, or balance cylinders should be of such a size as to provide an adequate unswept volume. It is understood that an appropriate practice is for the surge tank or unswept volume of a halance cylinder to be five times that of the swept volume of a halance cylinder. Valves should not be interposed between surge tanks and balance cylinders. The air inlet to halance cylinders should be so situated as to prevent accumulation of water in the bottoms of the vessels.

6. All piping, piping fittings, passages, surge or storage tanks, cored holes or drilled holes, shall be free from burrs or foreign matter which might cause damage to valves or clutch operating parts. Sharp edges should he removed wherever they may adversely affect the flow of air.

7. Whenever practicahle, each run of piping should he integral and continuous from one piece of apparatus to another. Piping runs should be removable without dismantling equipment components and without hending tuhing or springing it in a manner likely to damage it. Rigid piping should be securely supported at frequent intervals to avoid vihration or movement.

APPENDIX 2

Air Control Equipment (excluding Electrical Equipment)

1. Clutch operating valves should be placed as close as possible to clutch operating cylinders. (The object of this is to avoid time lag and to prevent waste of air).

2. Operating valves should not depend for support on connected piping. (The object of this is to avoid undesirable effects from vibration which may affect both valves and piping.)

3. Operating valves should be so designed as to ensure that when in the idling or non-operating position, leakage of air past the inlet valve will escape to atmosphere sufficiently freely to prevent build up of pressure in the clutch operating cylinder.

4. Operating valves should be so designed that it is not possible for both the inlet port and the exhaust port to remain closed at the same time.

5. Exhaust ports and piping between clutch operating cylinders and valves should be of sufficient capacity to ensure prompt release of air from clutch operating cylinders.

6. Control valves should be mounted in positions which provide complete accessibility without interfering with adjacent equipment.

7. Control valves should be so designed, placed or enclosed as to prevent intrusion of foreign bodies or exposure to inadvertent jamming.

8. Where valves are manually or mechanically operated (as distinct from electrical means) the arrangements for restoring the valves to the clutch disengage position at the end of the cycle, should be positive in character.

9. Where valves are operated by pilot systems, it is recommended that arrangements should be adopted which ensure immediate release of air pressure from the clutch and brake mechanism in the event of failure or partial failure of the pilot system.

APPENDIX 3

Electrical Equipment and Control

1. Electrical Supply for Control Circuits

The control circuit, whereby the cyclical working of the press is achieved, should be separate and distinct from the working circuits of other electrical apparatus, including that for driving the machine. The arrangement for supplying the control circuit should be through a voltage reducing double-wound transformer with centre-tapped secondary winding: the voltage of the control circuit should not exceed 110. The centre-tapping should be earthed and in addition earth leakage protection should be provided. The protection system when operated should actuate the main circuit breaker controlling the supply to the press. The press driving motor must be up to full speed before there is any response to the clutch controls. Where a reversing switch is provided this should not operate except when the press driving motor is at rest.

All wiring to switches, push buttons and other apparatus should be by tag connections and not by twisted wiring.

The electrical installation should be in other respects in accordance with British Standard 2771/1956, Electrical Equipment of Machine Tools.

2. Selector Switches

Where alternative methods of operation of the press are provided, e.g., " Run ", " Inch ", " Long " or " Hold ", a selector switch should be provided, and it should be so designed that it can be locked at each station so as to prevent accidental movement to another station.

Note by Joint Standing Committee. We understand that "locked" in this Recommendation means " set " or " fixed ", and does not necessarily mean the use of a key.

3. Operators' Controls

Definition. The expression " Button " means a hand-operated switch which is provided for the use of personnel for the purpose of operating a clutch control circuit.

(*a*) Stop Buttons

Stop buttons should conform to the following standards:

(i) They should be such that the part operated by the hand projects clear of the housing, e.g., of the mushroom or " palm " type.

(ii) The surface operated by the hand should be not less than 2 inches in diameter and should be coloured Red.

(iii) They should be so designed that they cannot be inadvertently jammed or otherwise prevented from being freely operated.

(iv) There should be one Stop Button per operating station as a minimum, i.e., where there is a Start Button there should be a Stop Button. In addition, where there is access at the back of a press, a Stop Button should be provided even though no operator works there.

(v) Stop buttons may be provided with arrangements which lock them in after operation.

(vi) No stop button, after operation, should re-start the cycle, when released or re-set.

(*b*) *Operating Buttons* (this Clause is intended to apply both to Run or Inch Buttons except where the contrary is indicated).

Operating buttons should conform to the following standards:

(i) They should be of such a design that they cannot be wedged or otherwise held in an unauthorised manner in the operating position.

(ii) Where more than one Operating (Run) Button is provided there should be proper means for " locking-in " but such arrangements should be such as to ensure that all the buttons cannot be locked-in at the same time. This requirement may be met, for example, by appropriate systems of selection or by arranging that one button is of a kind which cannot be locked-in.

It is particularly important that buttons should be so designed that they may not be inadvertently locked-in by mechanical failure.

" *Locking-in* "

Locking-in is understood to mean that an operating button is, for the time being, a permanent link in the control circuit.

(iii) Suitable fixed protective shrouding should be fitted with the object of preventing accidental operation.

(iv) Where operators' buttons are mounted on portable pedestals, particular care should be taken to ensure stability and also to provide effective shrouding to prevent accidental operation. Inch buttons should not be installed on portable pedestals or other adjustable mountings.

(*c*) *General Points of Design*

(i) Buttons should be so spaced that their centre points are at least 4 inches apart.

(ii) The function of each button should be clearly indicated.

(iii) The " display " of control buttons should be so arranged in a standard order. A vertical arrangement is preferred with the " stop " button at the bottom, the " run " button at the top.

(iv) Buttons should be so constructed that overload pressure on the operated part cannot be transmitted to the interior mechanism of the button.

4. Solenoids

Solenoids should be arranged to operate in a vertical direction and they should be enclosed in dust-tight covers. The enclosing arrangements should be such that the solenoid will not be operable unless the cover is in position.

5. Slide Adjustment Motors

Provision should be made to ensure that a slide adjusting motor cannot be set in motion while the clutch control circuit is energised.

6. Limit Switches

(*a*) Switches intended to terminate a cycle should be opened positively by cam or other appropriate mechanical action.

(*b*) The mechanical arrangements adopted for operating limit switches should be such that the roller and cam or other device is adequately proportioned and made of appropriate material to withstand wear which might lead to ineffective actuation of the limit switch. Steps should be taken to ensure that the means of operation of the switch and the switch itself are maintained in their correct relationship.

(*c*) Where it is considered that operating levers and/or rollers which are incorporated in limit switches are not adequate for cyclical working, separate mechanical linkages should be provided.

(*d*) (i) Limit switches should preferably be so designed that the action of finally opening the contacts should not depend on a spring but should be positively mechanical.

Note by Joint Standing Committee. We infer that reliability is the real criterion.

(ii) The electrical contacts should be of liberal rating so as to provide adequate safeguard against fusion. This may be achieved by the use of specially suitable materials which are quite readily obtainable.

(iii) Electrical conductors should be sufficiently rigid, so supported and spaced that a short circuit will not occur by arc-over or " tracking " due to creepage.

(iv) The design should be of a kind which will withstand vibration and prevent the ingress of dirt, damp, dust, fumes and oil.

(v) Limit switches should be designed with a liberal degree of overtravel.

N.B.—Many proprietary switches embody overtravel of 200% or more.

(*e*) If a limit switch is operated by a cam, the cam should be so designed that reverse rotation will not damage the limit switch.

7. American Practice

In the course of a study of American practice, the following points were noted :—

(*a*) A Zero speed or anti-plugging switch should be provided on the main motor to ensure that it could not be energised to run in the opposite direction while the armature was in motion.

(*b*) The main motor reversing contactors should be mechanically and electrically interlocked.

(*c*) For the RUN control, double relays should be used having one contactor of each relay in series with each solenoid where dual air valves are used. If one relay should fail to release the other one would stop the press.

APPENDIX 4

Friction Clutch and Brake Design

1. These recommendations are intended to be of application to clutches which are actuated by means of compressed air or electricity.

2. Clutches and brakes should be designed so as to perform satisfactorily when engaged and disengaged momentarily each time the top dead centre position is reached, under conditions of maximum sustained production.

3. The design should provide for adequate dispersal of heat so as to prevent excessive temperature rise of the working parts.

4. Sufficient working clearances should be provided so as to ensure that under the severest conditions of operation, friction drag leading to undesired movement of the driven members will not take place.

5. Arrangements should be made to prevent the accumulation of debris evolved from frictional surfaces, in places where it might give rise to clutch drag or seizure, and for its effective dispersal.

6. All practicable steps should be taken to avoid the possibility of corrosion. This applies particularly to air cylinder surfaces.

7. Effective means of lubrication of bearing surfaces should be provided, or such other treatment given as will minimise the chance of scuffing or seizure.

Particular attention should be given to the means of lubrication of the continuously rotating member.

8. Consistent with other mechanical considerations, the stage between brake release and clutch engagement, and between clutch disengagement and brake application, should be as small as possible in dimension and in time.

9. The springs used for applying the brake and withdrawing the clutch should be safely rated and be sufficient in power to secure prompt clutch withdrawal and effective brake application. Where springs are disposed on a pitch circle, care should be taken to ensure that all the springs are closely uniform in dimension and rating. A single spring should not be relied upon for this duty.

The means for loading the springs should be such that when appropriately adjusted, the springs can be locked to prevent risk of slacking back.

The arrangements for spring housing, guiding, and of guide pins should be such as to minimise the risk of binding.

10. Where a clutch and brake is operated by a diaphragm, special care should be taken to avoid damage to the diaphragm, e.g., by the cutting effect of sharp edges.

11. Effective arrangements should be made to prevent the penetration of oil to brake friction surfaces.

12. A fly-wheel brake should be provided which can be applied when the motor is switched off. Arrangements should be further incorporated which will ensure that when the brake is applied the control circuit will be isolated so that the clutch cannot be engaged while the fly-wheel is not in motion. The brake should be capable of arresting the continuously revolving parts in not more than 60 seconds.

APPENDIX 5

Emergency Overriding Anti-Repeat Valve Operated in conjunction with a Guard

The arrangement ensures that if the press should attempt to make a stroke unexpectedly with the guard in the position where it permits access to the dies, any pressure of air in the clutch cylinder will be exhausted to atmosphere and the clutch will be disengaged and the brake applied.

Referring to Figs. 1, 2 and 3, a press of the double sided type is fitted with a guard A. on each side. On depression of foot switches compressed air is supplied to the cylinders B. and the guards move outwards and upwards to the safe position. Cams C. are each rotated by the action of their respective guards and operate limit switches. These limit switches complete the run control circuit and the clutch engages. At the end of the down stroke the guards commence to return to their initial position. The clutch normally will disengage at the top dead centre.

Two cut-off valves D. are connected by a pipe E. to a point in the clutch air pipe between the normal operating valve and the clutch cylinder. The pistons of the valves D. are arranged so that the internal pressure of the system tends to push them to the exhaust position so that air will escape to atmosphere through the ports F. When the guards move outwards the cut-off valve pistons are pushed by the linkages G. into the position where the ports are closed. In addition, the hooks H. come into engagement and hold the pistons. When the guards are returning to their inner positions while the press slide is rising, the hooks maintain the pistons in the closed position so that the press will continue to the end of the up stroke. The final movement inwards of the guards disengages the hooks and the valves are then opened so as to open the cut-off valve ports to atmosphere. Either of the two valves is capable of bringing the press to rest.

APPENDIX 6

Anti-Repeat Safety Circuit for an Electro-Pneumatic Operated Press with Fault Indication

A safety air valve is placed in the air pipe leading from the normal control valve to the clutch cylinder. This valve, which is pilot operated, is controlled by a solenoid which is normally energised. In the event of a fault developing in the electrical control circuits so that the press would make a further stroke beyond the intended one, the safety valve solenoid would be de-energised and the valve would open the clutch air pipe to atmosphere, thus bringing the press to rest. This apparatus involves the provision of an additional cam on the timing cam shaft, which is concerned with the normal functioning of the press. The apparatus ensures that the press will be brought to rest in the event of any of the following events:

(1) The control valve jams in the open position so that the press would repeat.

(2) Sticking in of the clutch contactor.

(3) Sticking off of the timer, which is a necessary feature of the safety device.

(4) Sticking on of the timer.

(5) Burn out or open circuit of the safety air valve solenoid.

Indicator lights are included to show the existence of the above faults. After the operation of the emergency valve, no further movement can be obtained from the press except after the operation of the reset feature which necessitates the services of two men, one clearing fault at electrical control panel and holding in reset button, the other at operators starting switch gear, both being essential before press can be put back into production.

Note.—When the press uses independent air systems for clutch and brake, two safety air valves are used in parallel electrically.

Description of Anti-Repeat Safety Circuit

(*See Figs.* 4, 5 *and* 6)

Normal Operation

When main switch is closed, 400 volt supply is connected to L1 and L2, AV is energised *via* SL1. MC closes *via* AV1, making supply available for control circuits.

When start button is pressed, B1 is energised releasing brake, BLS closes energising M engaging clutch. M1 closing, retains clutch and brake contactor. When air pressure in clutch cylinder has built up, CPS closes and energises B2. B1 and B2 are in parallel to brake solenoid and ensure that brake is not applied until clutch is released.

T is energised at the same time as B1, closing contacts T1, T4, T2, and opening contacts T3. T is de-energised by B2. Contacts T1, T3, T4 start to time out, delay being 180° of stroke; by this time safety limits SL1 and SL2 have opened and reclosed but have had no effect as timer has cancelled them out.

At 265° 1LS opens, and closes at 300°. If start button has not been released NVR1 and 2 will remain open, and a second stroke cannot be made until start button is released and repressed.

Limit switches 2LS or 3LS will stop press at top of stroke depending on which position the selector switch is set.

Safety Device Action

If after completion of stroke, clutch contactor M has stuck in, M1 will remain closed, brake also will be held off because CPS will not have opened, and press will start to repeat. After 30° of stroke SL1 and SL2 will open, and as timer T has not been energised again because B2 - 3 is held open by brake contactor, T1 has not cancelled SL1; so AV safety air valve is de-energised and clutch is exhausted. AV1 opens, de-energising MC, MC1 and MC2 open disconnecting main supply completely from solenoids, control gear, and also main driving motor. Only a 12 volt supply is left alive to operate fault indicator lamps; in above example M3 would be closed because clutch contactor M is jammed in and fault lamp Z will light.

If clutch air valve fails to operate when de-energised by 2LS, SL1 will again open safety valve and cut off all current to controls, this time LPS will change over contacts because air pressure will exist between clutch and safety air valves; appropriate fault lamp Y will light.

All the safety equipment will "fail safe" if a fault develops. If safety contactor coil MC burns out, supply will be cut off to controls, main motor, etc., clutch exhausted and brake applied immediately.

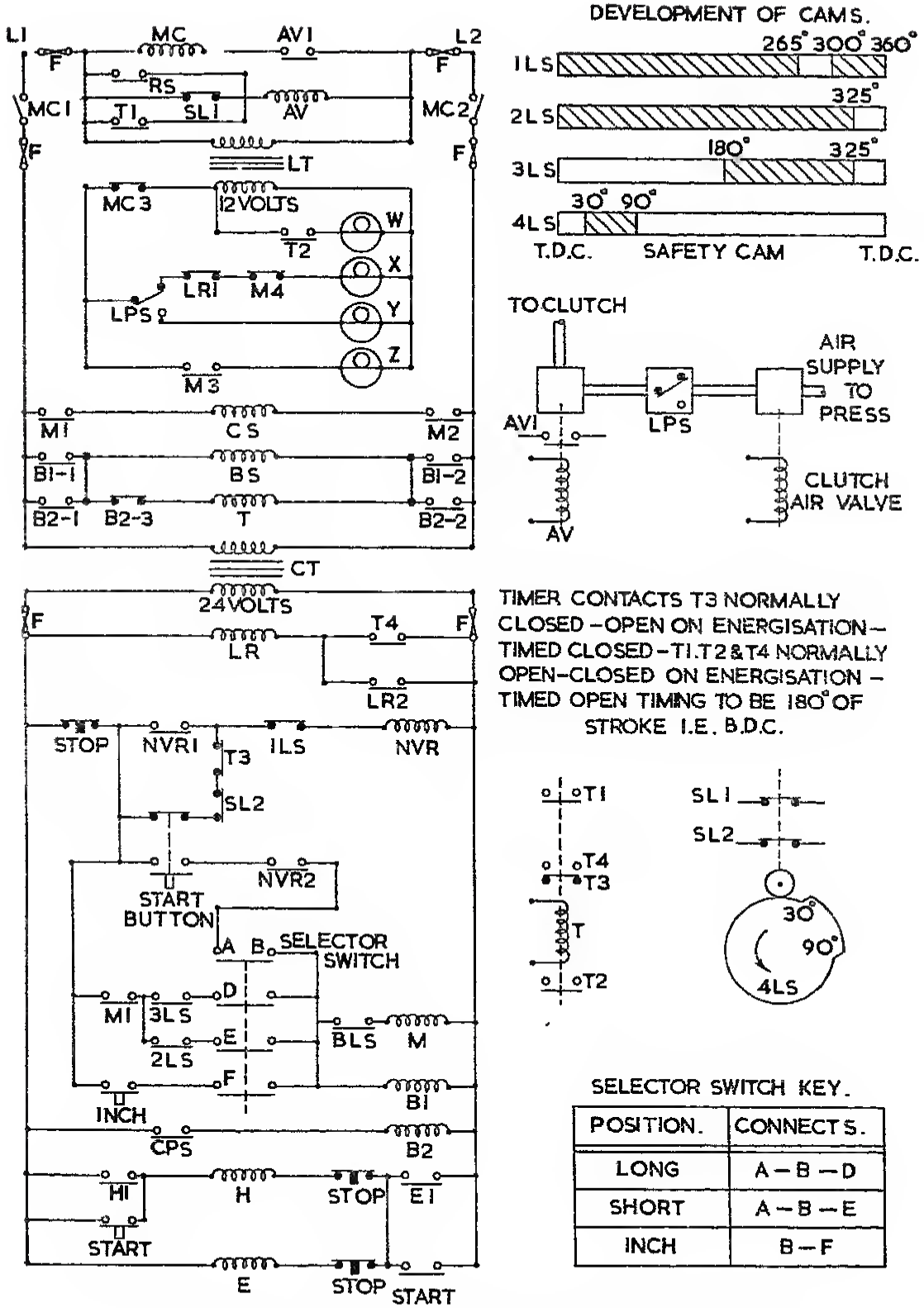
If safety air valve coil AV burns out, the same result will take place.

If timer coil T burns out or safety limit SL1 fails to close, press will again be stopped.

If timer T is energised but fails to time, or SL2 fails to close, press will complete the first started stroke, but cannot be restarted.

After a fault causing safety air valve to operate, press cannot be restarted until the following has taken place:—

1. Fault rectified.
2. Reset push button (in locked control panel) held closed; this temporarily restores supply to controls.



SELECTOR SWITCH KEY.

POSITION.	CONNECTS.
LONG	A – B – D
SHORT	A – B – E
INCH	B – F

Fig. 6. Wiring diagram of safety circuit (see also description of operation).
(Key to symbols overleaf.)

3. Main motor restarted, selector switch set to "inch", press inched round to top dead centre; only then may reset button be released. If released before this operation is complete, all current will again be cut off.

Two men are necessary to restore press to working order after safety device has operated.

AV	SAFETY AIR VALVE : NORMALLY ENERGISED
B1 and 2 ...	BRAKE CONTACTOR
BLS	BRAKE LIMIT SWITCH
BS	BRAKE SOLENOID
CPS	CLUTCH PRESSURE SWITCH
CS	CLUTCH SOLENOID
CT	24v. CONTROL TRANSFORMER
E	OIL PUMP MOTOR CONTACTOR
F	FUSES
H	MAIN MOTOR CONTACTOR
LPS	INDICATOR LIGHT PRESSURE SWITCH
LR	INDICATOR LIGHT RELAY
LT	12v. FAULT INDICATOR TRANSFORMER
M	CLUTCH CONTACTOR
MC	SAFETY CONTACTOR
NVR ...	NO-VOLT RELAY
RS	RESET SWITCH
SL	SAFETY LIMITS
T	TIMER
W	"TIMER STICKING OFF" INDICATOR LIGHT
X	"TIMER STICKING ON" INDICATOR LIGHT
Y	"AIR VALVE JAMMING ON" INDICATOR LIGHT
Z	"CLUTCH CONTACTOR STICKING IN" INDICATOR LIGHT
1LS - 4LS ...	LIMIT SWITCHES

APPENDIX 7

Disc-Brake Fault Detecting System (Patented)

The object of this device is to prevent the opening of a guard except under conditions where the brake is fully applied.

The press is fitted with an interlocking guard of the sliding type which must be in the closed position as a condition of the press operating. An interlocking air valve is inserted in the pipe leading to the clutch cylinder. This valve which is of the piston type has a tail rod which can interlock with the notch in a disc which is rotated by the action of opening and closing the guard. When the guard is closed and the normal control valve operated, air flows into the interlocking air valve and pushes the piston downwards so that the tail rod locks into the guard notch. At the same time air can flow through an uncovered port to the clutch cylinder. A supply of compressed air is taken from the main air supply and conveyed through piping to ports which are cut in the static plates of the brake. A connection from this piping system is also taken to two cylinders whose pistons are attached to the main air valve. When the brake is applied, the air bleed through the ports in the static plates of the brake is interrupted and pressure builds up in the pipe leading to the small air cylinders and in consequence the main interlocking air valve will lift and release the guard. It will thus be seen, that if the brake fails to apply effectively the bleed of air will continue and the guard will remain locked.

(This is a device patented by the British-Thomson Houston Co. Ltd., Rugby.)

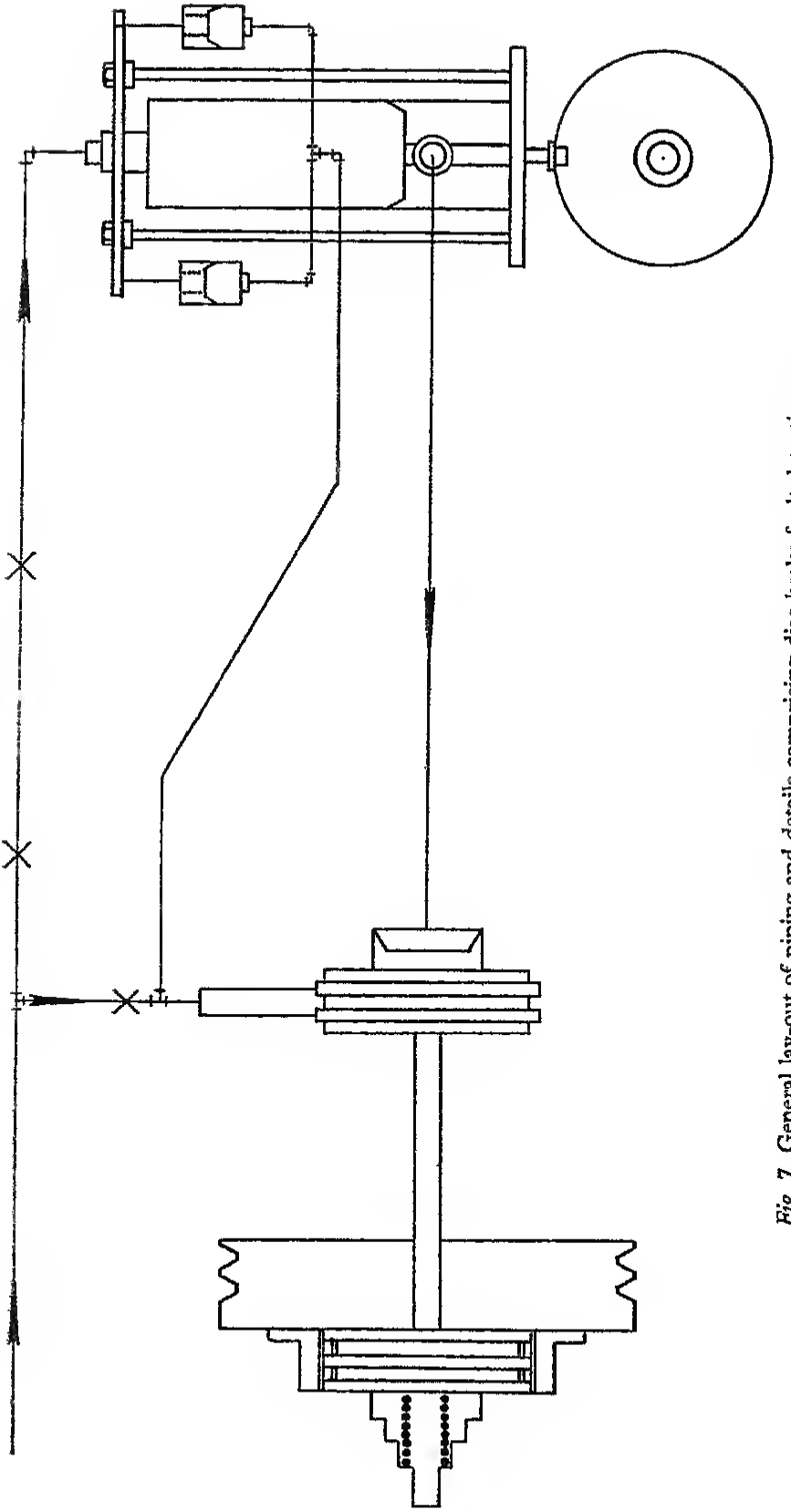


Fig. 7. General lay-out of piping and details comprising disc-brake fault detecting system.

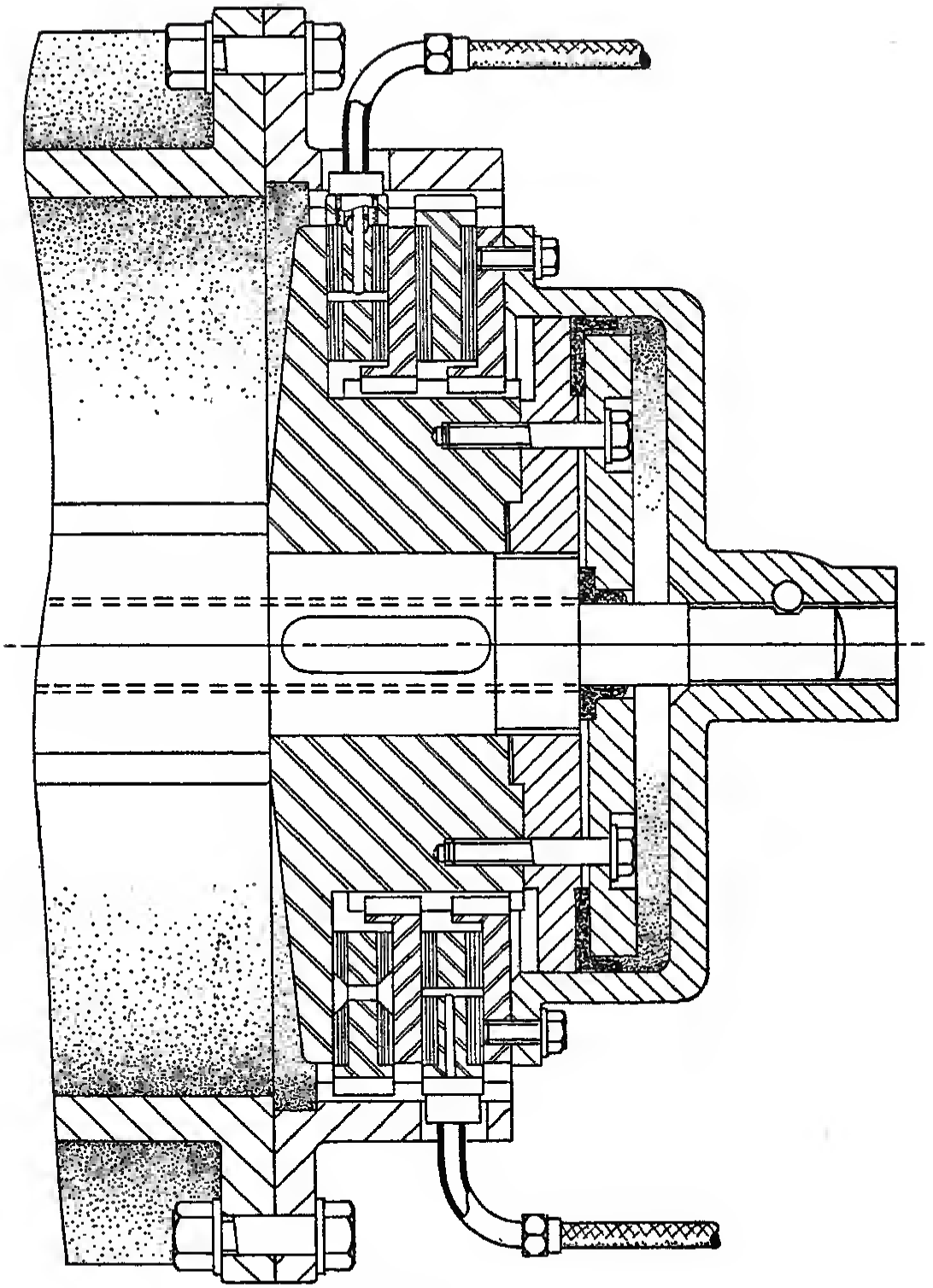


Fig. 8. Section through brake showing air bleeding connections.

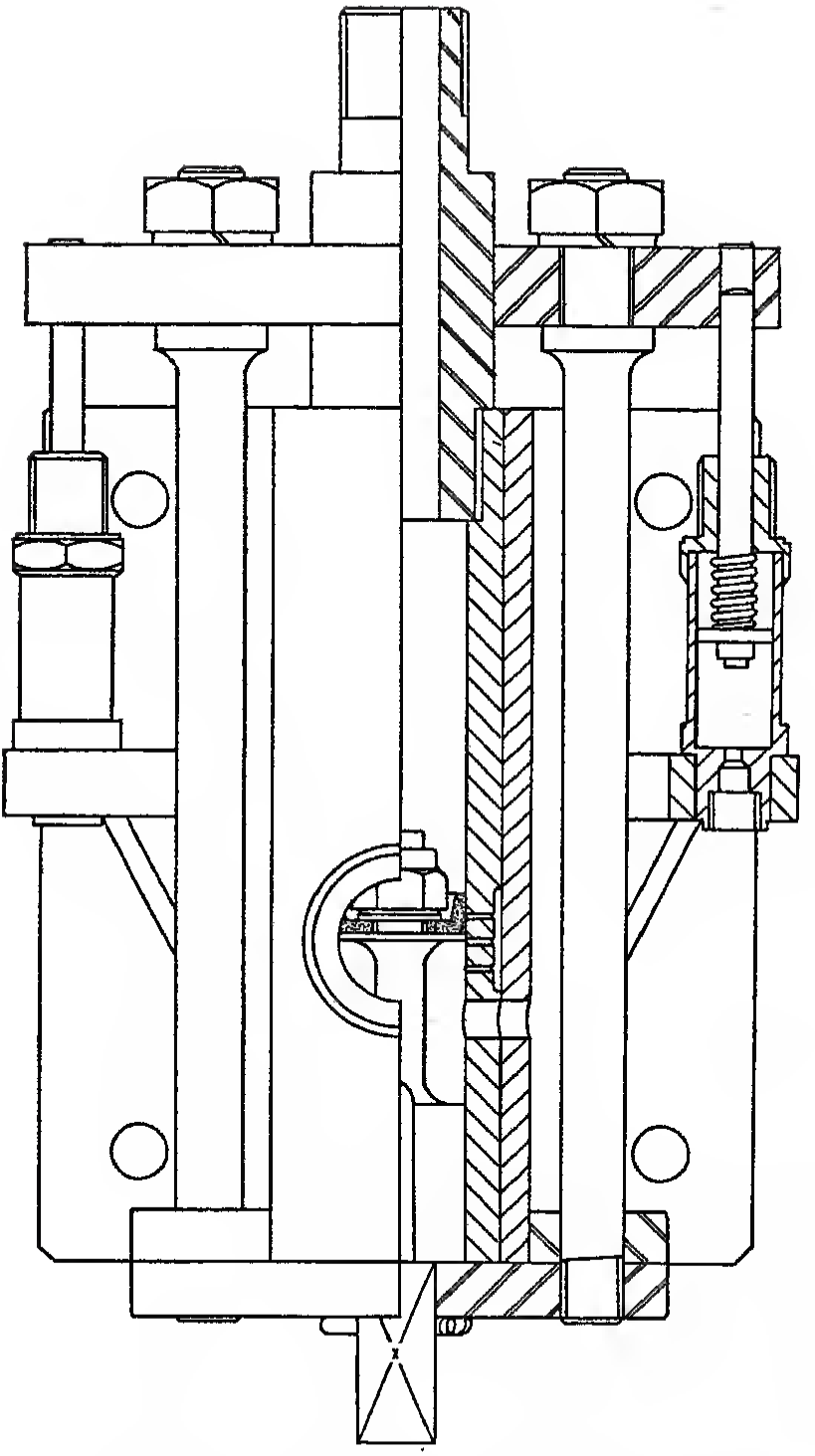


Fig. 9. Part-section through guard interlocking valve.

APPENDIX 8

Safety Control of Pilot-Operated Control Valves

Description of Valve

The objective in the design of the valve was to provide an arrangement which would under all conditions fail to safety and thus preclude repeat strokes arising from valve failure. The design provides for a pilot-operated valve which always has forces which move the spool to the exhaust position which are greater than the forces available to move it to the pressure position. No springs were used. These objectives were achieved by providing a constant air pressure on the return side in conjunction with a Duplex pilot system.

Referring to Fig. 10, the solenoid pilot-operated systems are designated X and Z. These are electrically connected in parallel but the X system admits pressure air to cylinder A when energised, while Z system admits pressure air to cylinder B when de-energised. A port Y is continuously open to air line pressure and thus exerts a constant force on the rear face of the piston in cylinder A. On energising X and Z solenoids, air is exhausted from cylinder B and pressure is applied to cylinder A, causing the spool to move over to the operating position and to pass mains air. On de-energising the solenoids, A is opened to exhaust and pressure air is admitted to B which in conjunction with the constant pressure at Y, forces the spool to the exhaust position, shutting off mains air and exhausting the system. The proportions of the pistons and spool are such that there is normally five times the force available to return the spool to the exhaust position than to the operating position. When this ratio drops to 2/1 re-operation of the valve is prevented.

The valve will continue to function safely even when any of the following faults may develop:

(i) the operating pilot system sticks open and fails to exhaust, maintaining a constant pressure on A. The balance of forces will be such as to return the spool;

(ii) the return pilot system fails and no pressure is exerted on B when the solenoids are de-energised. The spool is returned by constant pressure;

(iii) excessive pressure on spool due to damaged seals or contaminated air supply.

As, however, the valve will continue to function after a fault has developed, a combination of faults could eventually cause a failure to danger. A monitoring system is therefore applied to effect a strict check of each function of the valve during each operation, so that should a fault develop a signal is received and the valve cannot be operated after attaining the exhaust position, until the fault has been rectified.

Monitoring system

Referring to the schematic circuit in Fig. 11, " E " and " P " are the two pressure switches operated from the pilot cylinders, and are in the position shown when there is pressure in the return side of the main spool and no pressure on the operating side.

Operation of the control switch energises Relay R1 through switches E and P, contact R1B closes and the exhaust pilot solenoid is energised. As soon as the pressure in the exhaust pilot chamber drops, switch E changes over and the operating pilot solenoid is energised. Immediately there is a build-up of pressure in the operating pilot chamber, switch P breaks.

Relay R1 is held on through contact R1A.

On releasing control switch both solenoids and R1 are de-energised and valve spool returns.

Should (*a*) pressure remain in operating pilot chamber,
or (*b*) pressure be low in exhaust pilot chamber,

switches E and P will not be positioned to enable R1 to be energised. Therefore further operation is precluded.

As a check against the contacts of R1 relay welding in a second Relay R2 is introduced.

When the control switch is released if contacts R1 are still closed, R2 is energised *via* R1C contacts. The normally closed contacts R2B are opened and R2 is "held" by contacts R2A.

As before, further operation is precluded until the fault has been rectified.

Note.—The valve is unable to distinguish between a true and false signal from the control switch, and therefore, where interlock guards are used therefor, it is advisable to wire a guard lock and release arrangement in parallel with R2.

In the event of the control switch failing to return, the guard will then remain locked.

(The valve and monitoring system are covered by patents held by Industrial Guarding Equipment Ltd.)

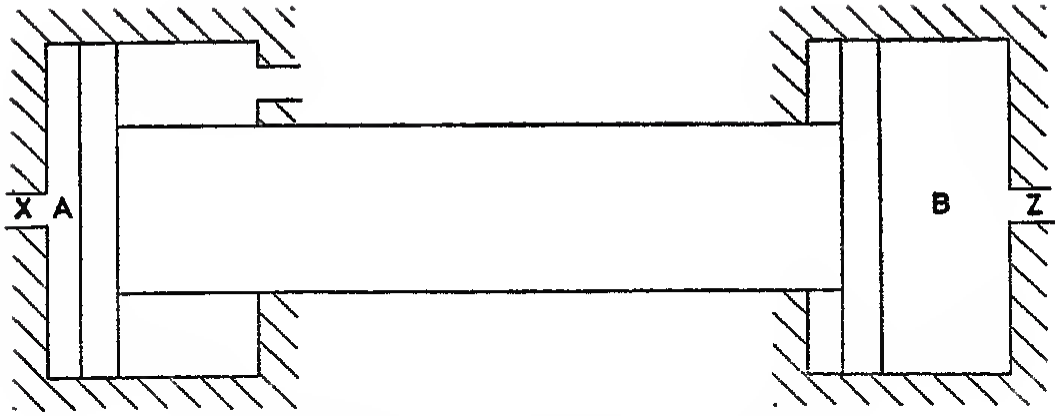


Fig. 10. Diagram of solenoid pilot-operated control valve.

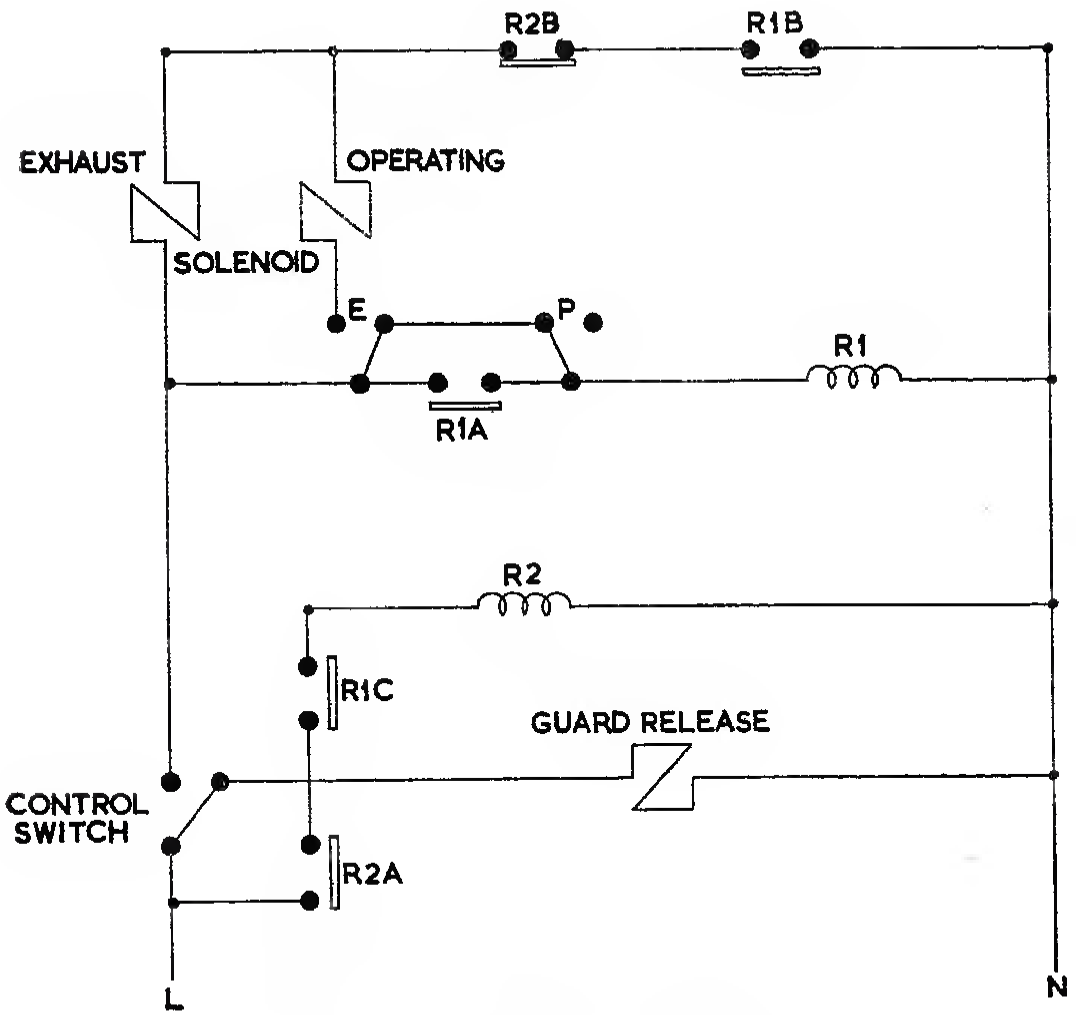


Fig. 11. Wiring diagram (schematic) for control valve.

ANNEXE 2

Mechanically Operated Overriding Anti-Repeat Safety Device

This device is designed to ensure that in the event of a press attempting to make a repeat or unintended stroke, the supply pipe to the air-operated clutch will immediately be opened to atmosphere. The clutch will then be disengaged and the brake applied. The application of the device shown here is to a press, open back and front, operated through an electrically-controlled air-actuated friction clutch.

Referring to Fig. 12, two single-acting air cylinders A. and B. are respectively connected to air pedal switches, one for each side of the press. The piston rods are cross-connected by a lever C. which is pivoted at its mid point to a slide rod D. The upper end of D. bears on the underside of cross lever E. At an intermediate point on E., connection is made to the rod of the emergency valve F. This valve is connected by pipe G. to the clutch air pipe at a point between the clutch valve and the clutch cylinder. In Fig. 12, the valve F. is open so that air pressure cannot build up in the clutch cylinder. The outer end of lever E. is designed so that when it is raised a pin on the bell crank H. will pass under lever E. and hold it, thus closing the emergency valve F.

Referring to Fig. 13, both pedals have been depressed causing lever C. to rise and through rod D. and lever E, closing emergency valve F. At the same time, by the movement of lever J., the re-set switch K. and the start switch L. have been operated so that the clutch engages. At or near the end of the crankshaft revolution, trip lever M. is raised to clear bell crank H. from lever E, and the emergency valve is opened. If, by reason for example of sticking of the clutch valve solenoid so that the clutch valve remained open, the normally ensuing repeat stroke would be prevented by the release of lever E, and opening of the emergency valve under the influence of the pressure within the clutch air pipe.

Fig. 14 shows the situation when one pedal valve only is depressed. Lever C. has not made its full upward travel and the start switch L. has not been actuated, neither has cross lever E. moved sufficiently far to close the emergency valve. If one of the foot valves should fail " open " then the re-set switch is not " made " and a further stroke cannot be obtained. Failure of both pedal valves would result in both cylinders A. and B. remaining charged but the pressure in the emergency valve cylinder, by reason of its size, would overcome cylinders A. and B. and the emergency valve would open.

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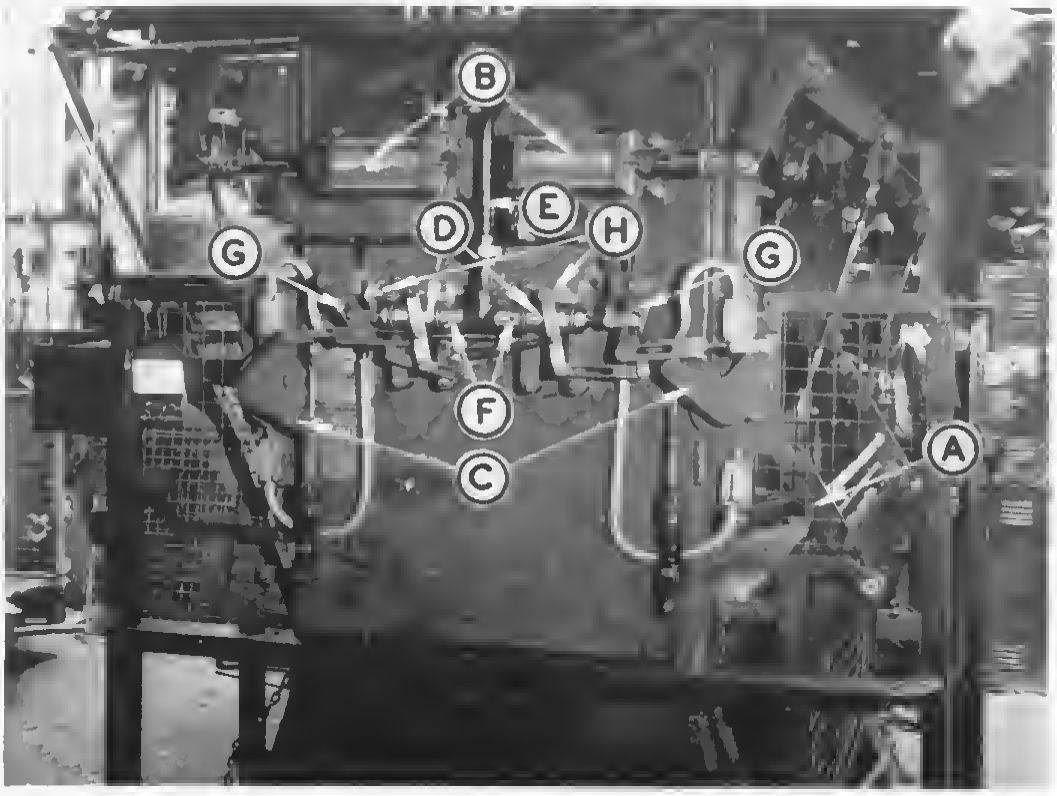

Fig. 1. This shows the right-hand guard in the inner or feeding position with its associated cut-off valve ready to open if an unexpected stroke should occur. The left-hand guard is extended and the associated cut-off valve is held in the closed position by the catch H. (a full description of the device is contained in Appendix 5).

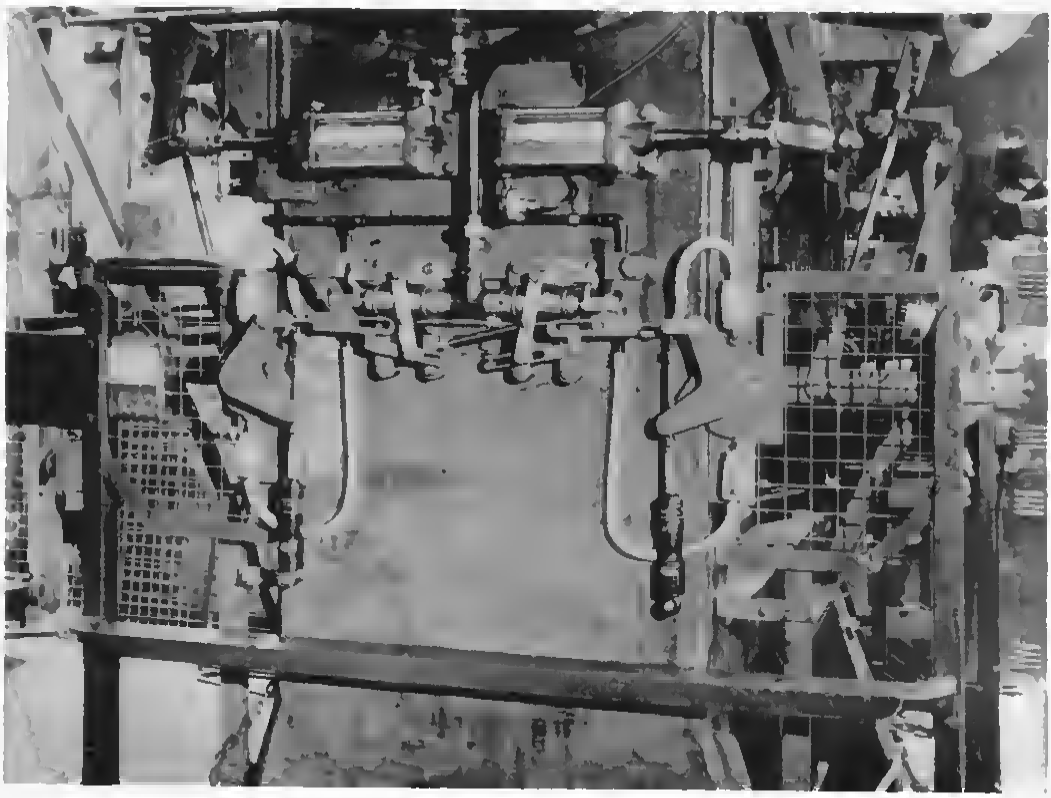

Fig. 2. Both guards are in the extended position and the cut-off valves are held by the locking hooks H.

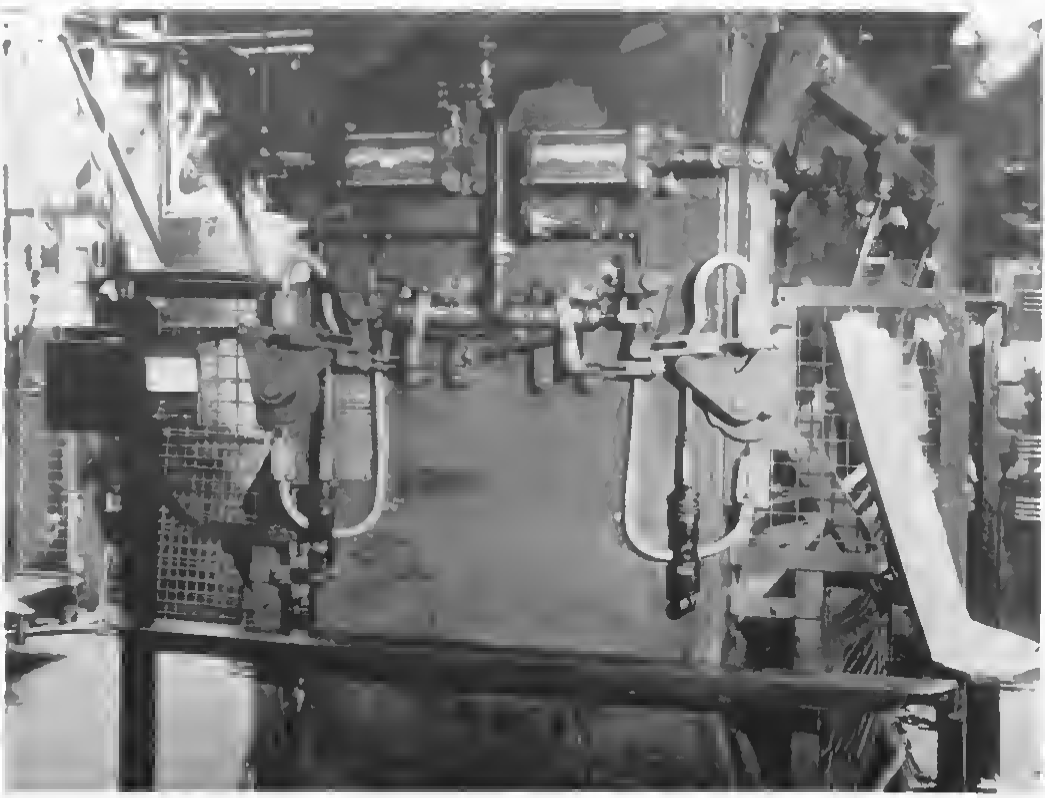

Fig. 3. Both guards are in the inner, or feeding, position and the cut-off valves have opened when an attempted repeat stroke is developing.

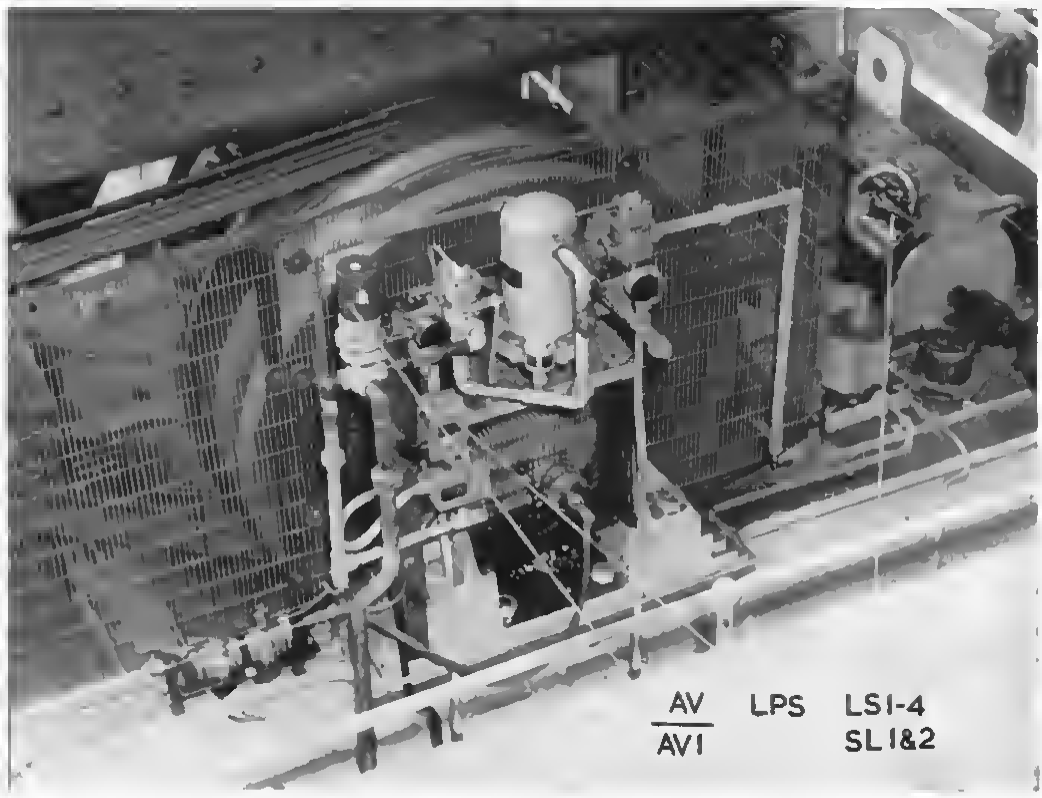

Fig. 4. General view of safety air valve AV/AV 1. LS 1 - 4 are the limit switches associated with the various cycles of working, and of the safety circuit described in Appendix 6.

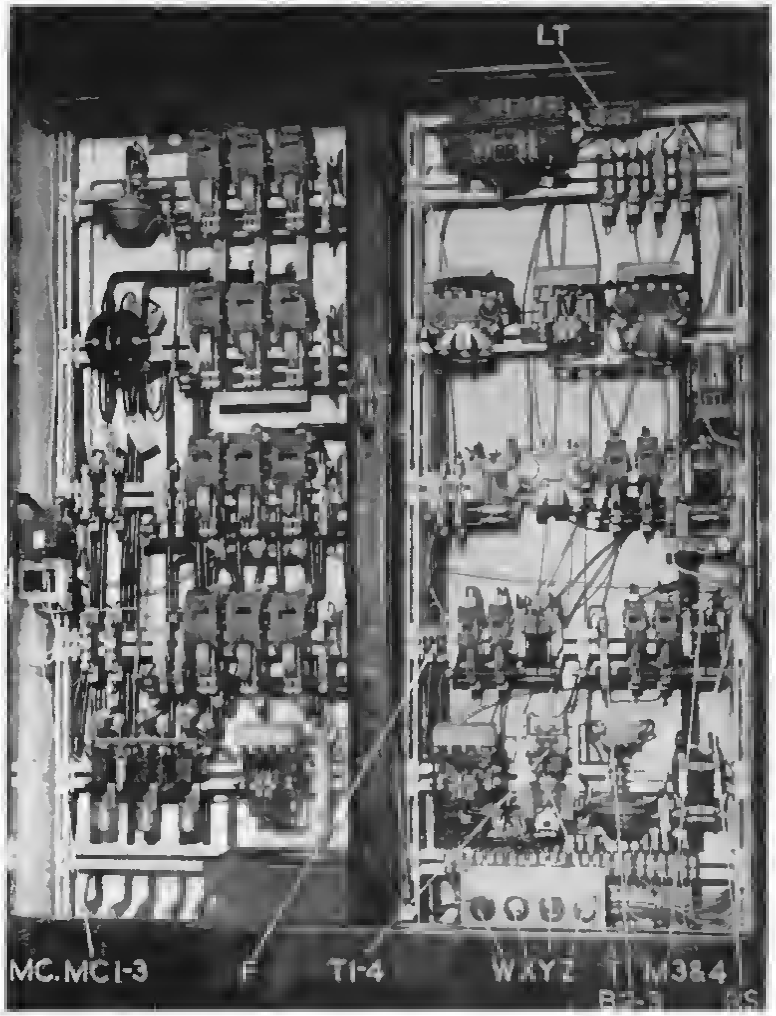

Fig. 5. Control cabinet showing additional equipment fitted for the anti-repeat safety circuit. (Appendix 6).

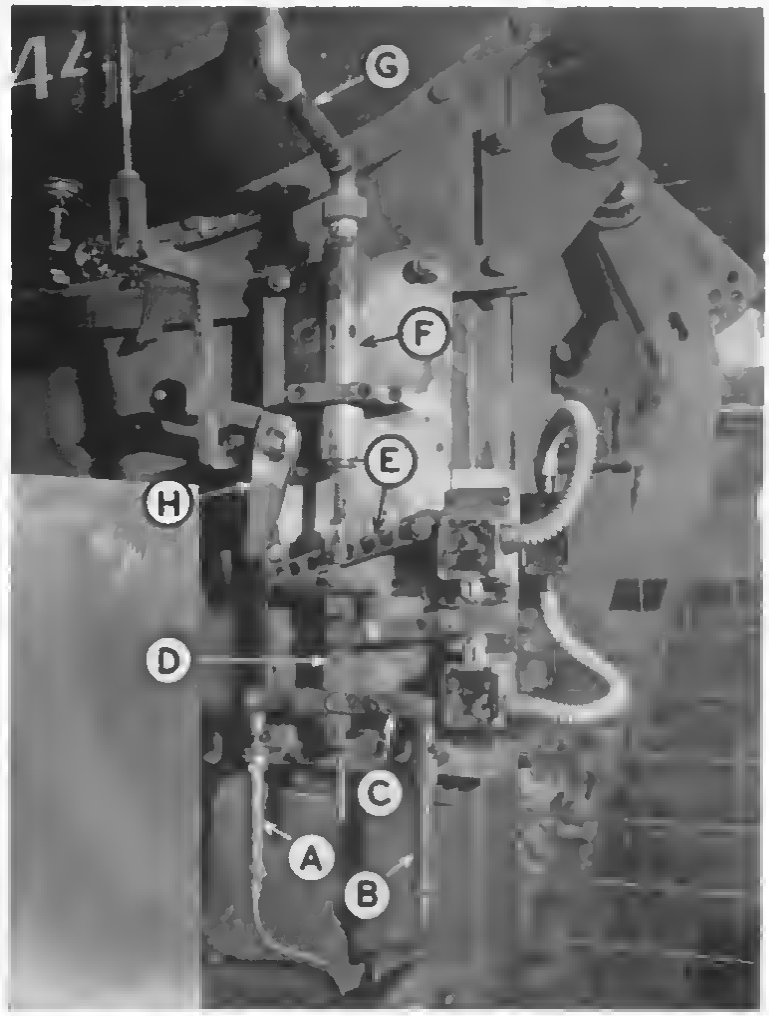

Fig. 12. (Annexe 2).

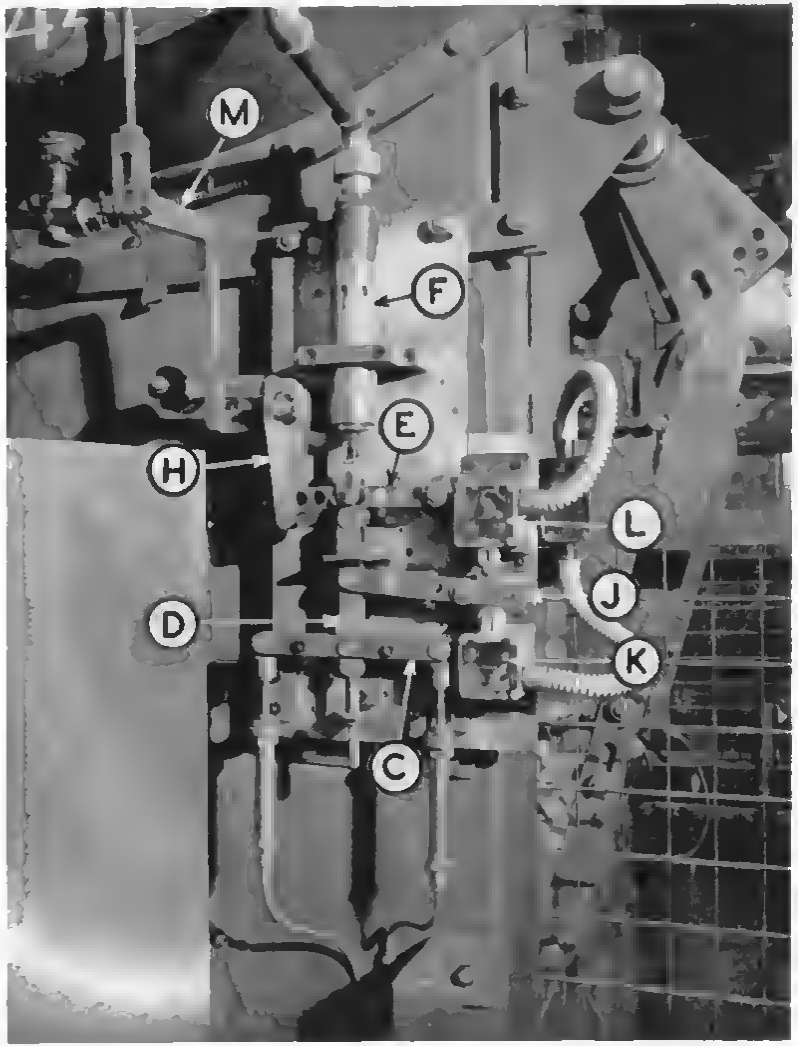

Fig. 13. (Annexe 2).

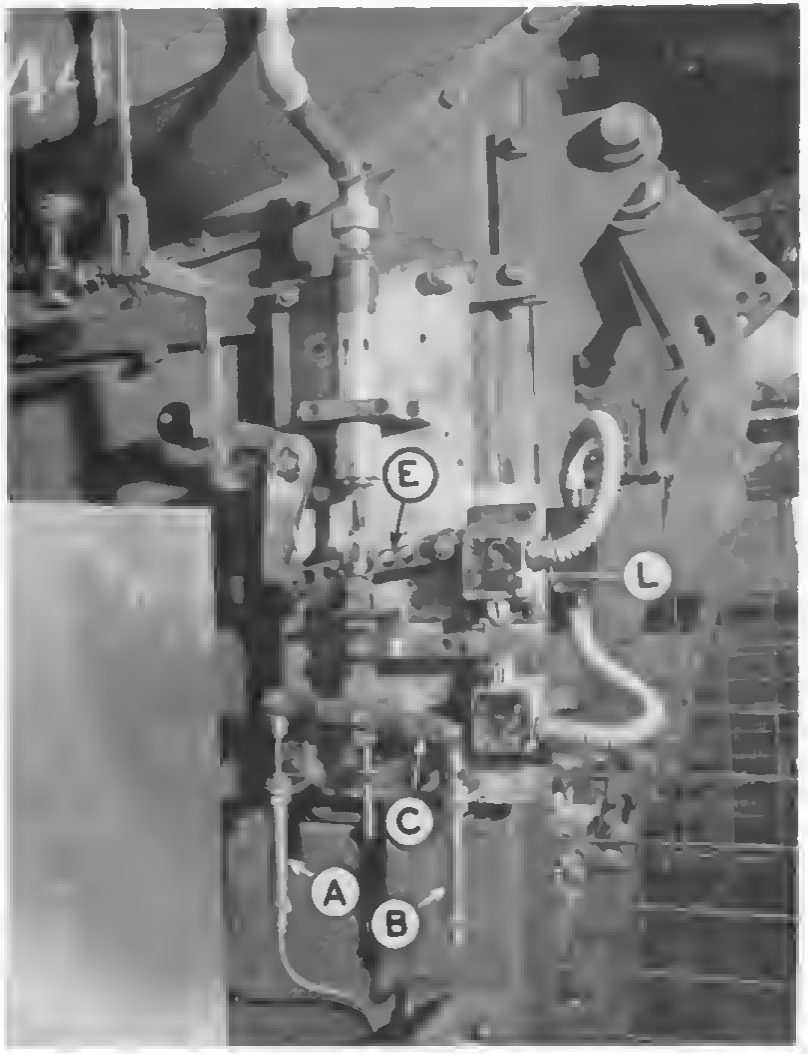

Fig. 14. (Annexe 2).